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MINUTES
OF THE ELEVENTH
EXPLOSIVES SAFETY SEMINAR

SHERATON-PEABODY HOTEL
MEMPHIS, TENNESSEE
9-10 SEPTEMBER 1969

VOLUME II

STATEMENT #4 UNCLASSIFIED

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MINUTES

OF THE [redacted]

EXPLOSIVES SAFETY SEMINAR (11th),

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12 37p.

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Volume II

"HOW SYSTEM SAFETY CAN REDUCE THE EXPLOSIVE HAZARDS"

BY

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SYSTEM SAFETY MANAGER
SRAM PROGRAM
AEROSPACE GROUP, THE BOEING COMPANY
SEATTLE, WASHINGTON 98124

Because of the short time allowed to present this topic, I cannot penetrate to the depth required to cover such a comprehensive subject. I hope I can stimulate enough interest for further discussion in our question/answer period.

The design, development, test and deployment of military weapon systems are usually associated with the use of hazardous materials. Chemical or nuclear energy sources to produce heat and overpressure effects are the most used. The paramount objective of the US Air Force Nuclear Safety Program is the prevention of accidential or premature occurrence of a nuclear detonation. Confidence that the events necessary to produce a nuclear yield, arm or fire a warhead, or release or launch a vehicle will not occur except when authorized. These same objectives generally apply to any weapon or hazard source. Since a nuclear weapon supposes cataclysmic consequences in the event of a catastrophy, a systems approach with total involvement of people, hardware, software, policy, concepts, etc., is necessary to assure a low level of risk.

The purpose of this presentation is to relate the concepts and methodology of System Safety to the reduction of explosives hazards. We can best fulfill this purpose by an example and examine some of the results of an integrated system safety program for a modern sophisticated weapon system called SRAM.

SRAM is the acronym for the Short Range Attack Missile capable of air launch from the B-52 and FB-111A aircraft. We also call it AGM-69A (Air to Ground Missile) or Weapon System 140A (Chart 1). When we refer to the Weapon System we include the aircraft and special "black box" equipment, the missile, people, Aerospace Ground Equipment (AGE), Technical Orders, Training Equipment. All the hardware, software, people and the systems necessary for acquisition.

The system features (Chart 2) indicate the interrelated aspects of missile safety, nuclear safety, range safety, ground safety, explosives safety, flight safety and

industrial safety are encompassed in this weapon system. The missile (Chart 3) is propelled by a split pulse type of booster/cruise Class II solid propellant motor. An iner .l/solid state computerized guidance system steers the missile, which is an aerodynamic shape, with moveable fins. Various ordnance initiated subsystems are used for ejection from the aircraft, battery activation, controls power boost activation and fins unlock devices. A linear shaped charge (LSC) is used on the missile motor for test launches to render the motor non-propulsive and meet range safety requirements.

Chart 4 is a paraphrased extract from the contract statement of work which requires systematic analyses and a mathematical model for probability prediction and assessment of numerical safety requirements. Chart 5 is a summary of the applicable specifications, manuals and regulations that specify qualitative design and operating safety requirements. One of particular interest is the application of MIL-STD-833, to minimize the hazards of Electro Magnetic Interference (EMI). All the SRAM squibs and ignition devices are designed to meet this standard to minimize premature or inadvertent ignition. I assume most of you are familiar enough, generally, with these requirements without dwelling on them. Charts 6 and 7 show the requirements to meet federal, state and local codes and insure protection of employees and property during manufacture and transport of explosive components.

The application of System Safety Engineering (Chart 8) consists of: analysis for identification of hazards by gross, subsystem and system analyses; categorization of the hazard as to degree of severity; necessary correction of the system to eliminate or reduce the hazard. Preliminary and Critical Design Reviews (PDR, CDR) are key correction points. Once hardware is built, the Engineering Change Proposal (ECP) implements changes. The system analyses culminate into inputs for the system math model, our major tool for assessing the degree of achievement of our numerical safety goals. (Chart 9). The system safety numerical requirements (Chart 10) are allocated by phases which are further allocated into the mission cycle (Chart 11).

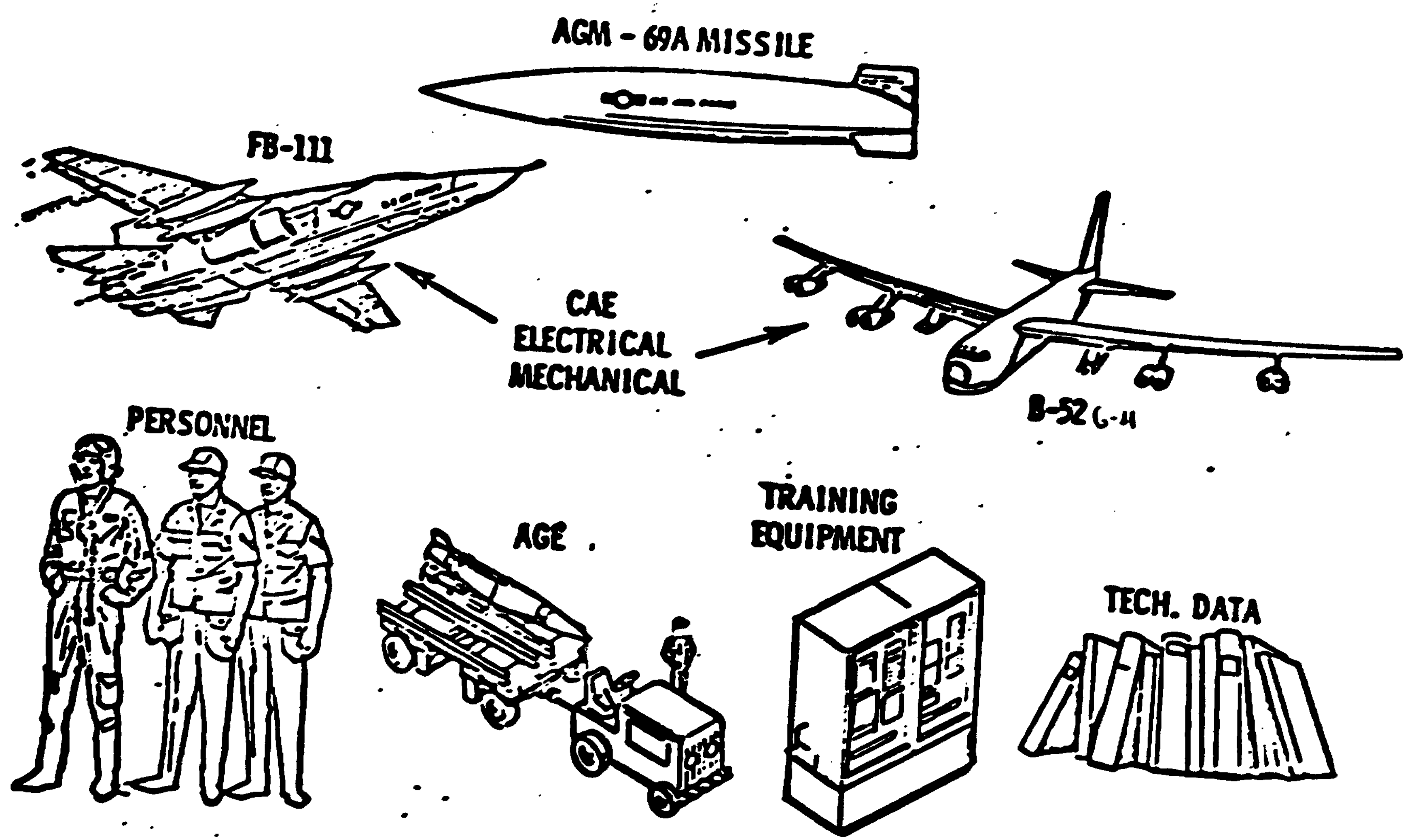
The logic model, for the numerical allocation and assessment program, uses the Fault Tree technique. Chart 12 shows the top system tree for the FB-111 and B-52 Emergency War Order (EWO) or Operational Test Launch (OTL) critical or catastrophic events. The hazardous events identified in the system (Chart 13) are identified by hazards analyses of the system. Probabilities for these events are allocated by phase and an assessment/prediction made by a computer simulation of over a million trials of the system model through its mission cycle. Data sources (Chart 14) draw from reliability, biotechnology and maintainability estimates for the system. The failure rates are inductively summed by Boolean to give the probability for the top events. The Monte Carlo technique is used to simulate the system model and derive the probabilities by phases.

An example of how the system fault tree/computer simulation technique can be used to predict explosive hazards, and evaluate the need for change to reduce the hazards and the effects, I would like to discuss some of the anulyses leading to the first live launch of a SRAM from the B-52. Chart 15 shows the major hazardous events that could occur during the launch. The hazard of most concern was a missile motor explosion prior to or after launch. Premature activation of the command destruct linear shaped charges could cause ignition of the propellant with case rupture and dispersal of motor case fragments. The events that could cause this are shown in Chart 16.

The other major event was a missile motor explosion caused by the events shown in Chart 17, which are in addition to failures in the motor mechanical components. Chart 18 shows the prediction for the first launch using a 1.5 second ignition time after release for the boost pulse. A probability of 1.44×10^{-4} was predicted for missile/carrier collision caused by fragments from a motor case rupture due to overpressurization striking the aircraft and causing critical damage. The relatively low probabilities for command destruct and premature ignition by the motor ignition circuitry indicated they were sufficiently safe. The most significant contribution to the event were physical failures in the motor. A secondary parametric study was made of the probability of motor case overpressurization (explosion) and the probability of fragments striking the aircraft and causing serious damage.

Charts 19 and 20 show the logic of events and probabilities for the motor explosion, 1.1×10^{-3}, which indicated a need to increase the separation time between the missile and aircraft since at 1.5 seconds ignition time the missile was only about 25 to 40 feet away from the aircraft. Using the model of Chart 21, which assumes the motor fragments in a subtended cone strike the aircraft, with the penetration criteria of Chart 22, and empirical data from motor firings which overpressurized and produced fragments, the graph on Chart 23 was derived from maximum penetration heights for critical wing panels on the aircraft. The Chart 24 was developed for the probability of fragments striking the aircraft at various separation distances. Using a 2000 foot separation distance (maximum fragment distance from motor firing data) a conservative 11.5 second delay was used for ignition time of the motor boost pulse. The predicted probability of 1×10^{-23} for one of 50 particles striking the aircraft gave an increase of some 20 orders of magnitude. A motor improvement program has been started to eliminate the cause of failure predicted by the analysis. As more empirical motor firing data are generated to indicate higher confidence with lower risk, the firing time for the motor will be reduced to the normal 1.5 seconds. Chart 25 is a summary of air launched missile incidents, including operational and development launches. It is interesting to note that these empirical data correlates with the current predictions for SRAM.

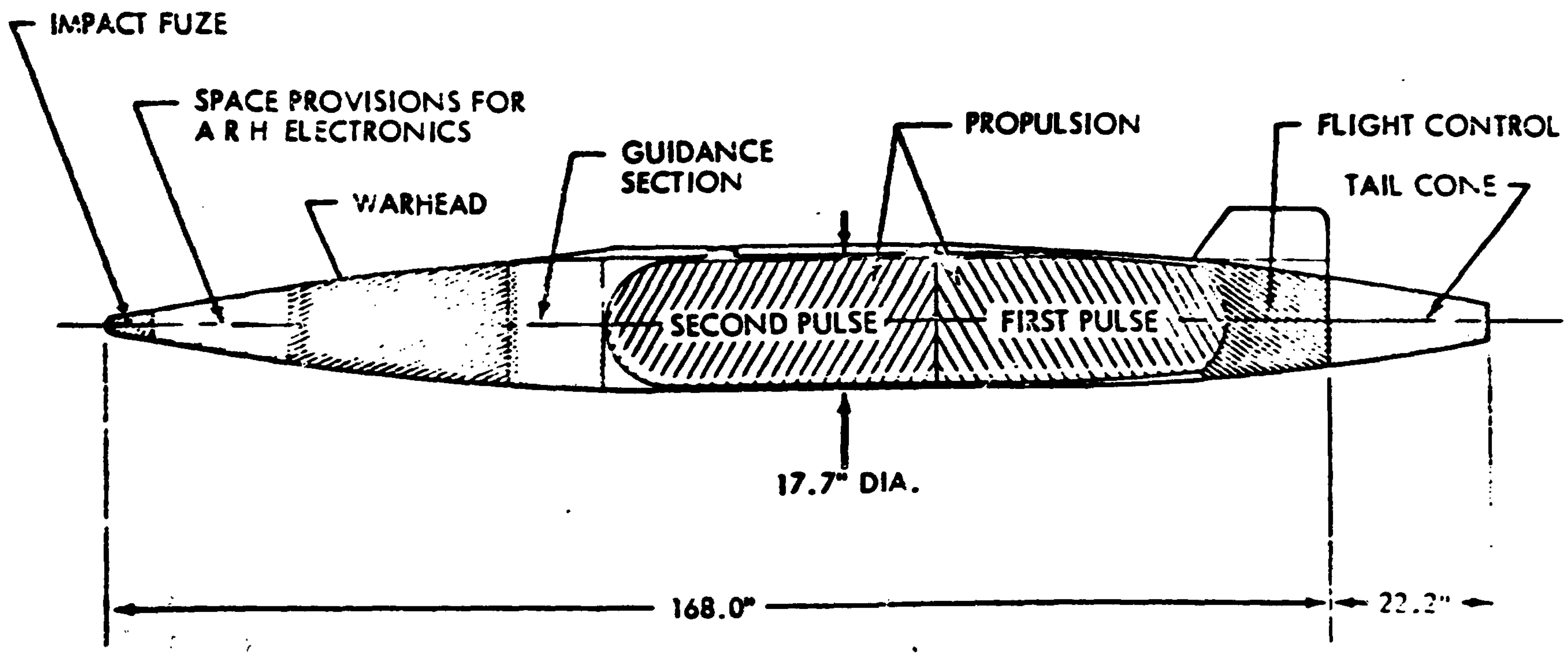
This briefly describes the degree of involvement required for a system safety analysis and how the hazards associated with the use of explosives can be effectively reduced.



THE AGM-69A SYSTEM
(WS-140A)

- MISSION AND PERFORMANCE
  - MULTIPLE ATTACK TRAJECTORIES
  - LAUNCH FROM LOW OR HIGH AIRCRAFT ALTITUDES
  - LAUNCH AT LOW OR HIGH AIRCRAFT SPEED
  - EXTERNAL AND INTERNAL MISSILE CARRY
  - HIGH PENETRATION VELOCITY
  - LOW RADAR CROSS-SECTION
  - ADEQUATE RANGE TO LAUNCH OUTSIDE DEFENSES
- HARDWARE
  - NUCLEAR WARHEAD
  - SOLID, SPLIT-PULSE PROPULSION
  - INERTIAL GUIDANCE
  - CARRIER AIRCRAFT EQUIPMENT

SYSTEM FEATURES



AGM-69A INBOARD PROFILE

- SAFETY ENGINEERING PROGRAM

  MIL-S-38130 AFSCM 375-5 AFSCM 375-1
  AFSCM 122-1 AFR 122-2 (NWSSG)

  - MATHEMATICAL MODEL AND PROBABILITY
  - SYSTEM/SUBSYSTEM ANALYSES
  - TRADE STUDIES
  - REVIEW ENGINEERING AND TEST DATA
  - TECHNICAL ASSISTANCE TO SYSTEM SAFETY GROUP
  - CORRECT SAFETY DEFICIENCIES
- SAFETY ENGINEERING DOCUMENTATION
  - DD FORM 1423 CONTRACT DATA REQUIREMENTS LIST

SYSTEM SAFETY REQUIREMENTS ~~(DDT&E)~~

SYSTEM SAFETY REQUIREMENTS (DDT&E)

ALSO MEET THE REQUIREMENTS OF:

MIL-S-38130	SYSTEM SAFETY ENGINEERING
AFSCM 122-1	NUCLEAR WEAPON SYSTEM SAFETY DESIGN MANUAL
AFM 127-100	EXPLOSIVE SAFETY
AFM 35-99	HUMAN RELIABILITY PROGRAM
AFM 71-4	PACKAGING AND HANDLING OF DANGEROUS MATERIALS FOR TRANSPORTATION
AFR 20-4	AIR FORCE ATOMIC ENERGY PROGRAM
AFR 122-4	TWO-MAN CONCEPT
AFR 122-5	SAFING AND SEALING
AFR 127-1	USAF AEROSPACE ACCIDENT PREVENTION PROGRAM
AFR 127-4	INVESTIGATION AND REPORTING ACCIDENTS/ INCIDENTS
AFM 127-20	MISSILE SAFETY
MIL-STD-833	MINIMIZATION OF HAZARDS OF ELECTRO-MAGNETIC RADIATION TO ELECTROEXPLOSIVE DEVICES
T.O. 11N-20-12	TRANSPORTATION AND STORAGE SAFETY FOR ATOMIC WEAPONS AND COMPONENTS

HEALTH AND SAFETY REQUIREMENTS

AGM-69A CONTRACT GENERAL PROVISIONS

CONTRACT REFERENCE	REQUIREMENTS
CLAUSE 17	WALSH-HEALEY SAFETY AND HEALTH STANDARDS
CLAUSE 63	SAFETY AND ACCIDENT PREVENTION
CLAUSE 64	SAFETY PRECAUTIONS FOR DANGEROUS MATERIALS
CLAUSE 65	SAFETY PRECAUTIONS FOR RADIOACTIVE MATERIALS
CLAUSE 68	ACCIDENT INVESTIGATION

HEALTH AND SAFETY REQUIREMENTS

LEGAL CODES, REGULATIONS, & STANDARDS—LOCAL, STATE, & NATIONAL BODIES

EXPLOSIVES TRANSPORTATION EXPLOSIVES REQUIREMENTS	CITY OF SEATTLE CITY OF KENT
GENERAL SAFETY STANDARDS OCCUPATIONAL HEALTH STANDARDS RADIATION PROTECTION STANDARDS LABELING OF HAZARDOUS SUBSTANCES EXPLOSIVES ACT MOTOR VEHICLE LAWS ELEVATOR STANDARDS	STATE OF WASHINGTON
ATOMIC ENERGY ACT NATIONAL FIRE CODES NATIONAL ELECTRICAL CODE	NATIONAL
CODES OF OTHER STATES	

SYSTEM SAFETY ENGINEERING (MIL-S-38130)

ANALYSIS	GROSS SUBSYSTEM SYSTEM
IDENTIFICATION	HAZARDS I II III IV
CORRECTION	PDR CDR ECP

SYSTEM SAFETY ANAYSES

• SYSTEM	GROSS HAZARDS INTEGRATION HAZARDOUS FAILURE MODE OPERATING
• SUBSYSTEM	FUNCTIONAL IDENTIFICATION HAZARDOUS FAILURE MODE ANALYSIS MALFUNCTION EFFECTS
• FAULT TREE	SYSTEM / SUBSYSTEM / COMPONENT — MATH MODEL PROBABILITY (1.2×10^{-4}) ASSESSMENT

SYSTEM SAFETY NUMERICAL REQUIREMENTS

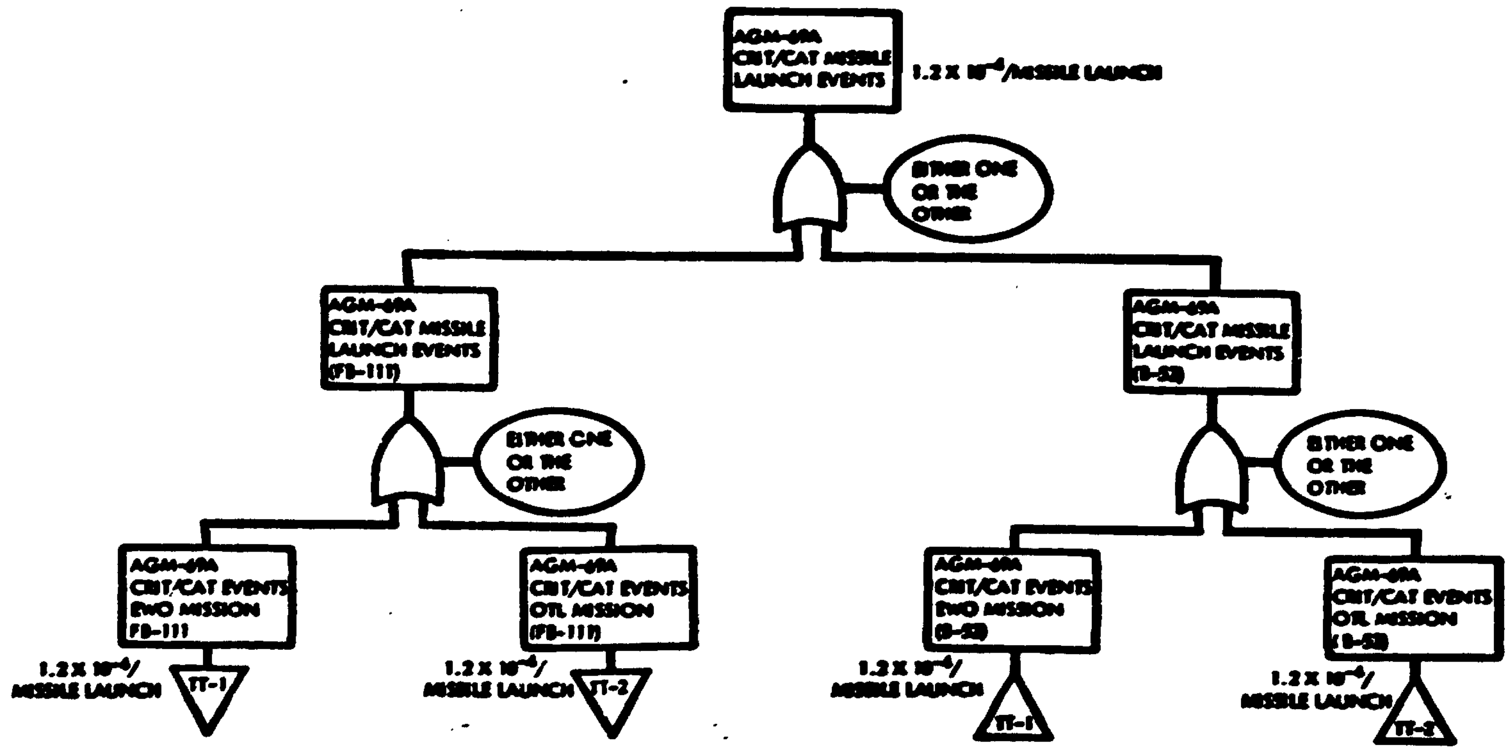
SYSTEM SPECIFICATION SSA 14000A

- TOTAL OF CRITICAL AND CATASTROPHIC EVENTS 1.2×10^{-4}/MISSILE LAUNCH
- PROBABILITY OF CRITICAL OR CATASTROPHIC EVENTS DURING:
  - (A) GROUND $< 1.7 \times 10^{-5}$/MISSILE LAUNCH
  - (B) CAPTIVE FLIGHT $< 5.1 \times 10^{-5}$/MISSILE LAUNCH
  - (C) FREE FLIGHT $< 5.2 \times 10^{-5}$/MISSILE LAUNCH
  - (D) TOTAL PROBABILITY OF A NUCLEAR EVENT SHALL BE LESS THAN 1×10^{-8}/MISSILE LAUNCH

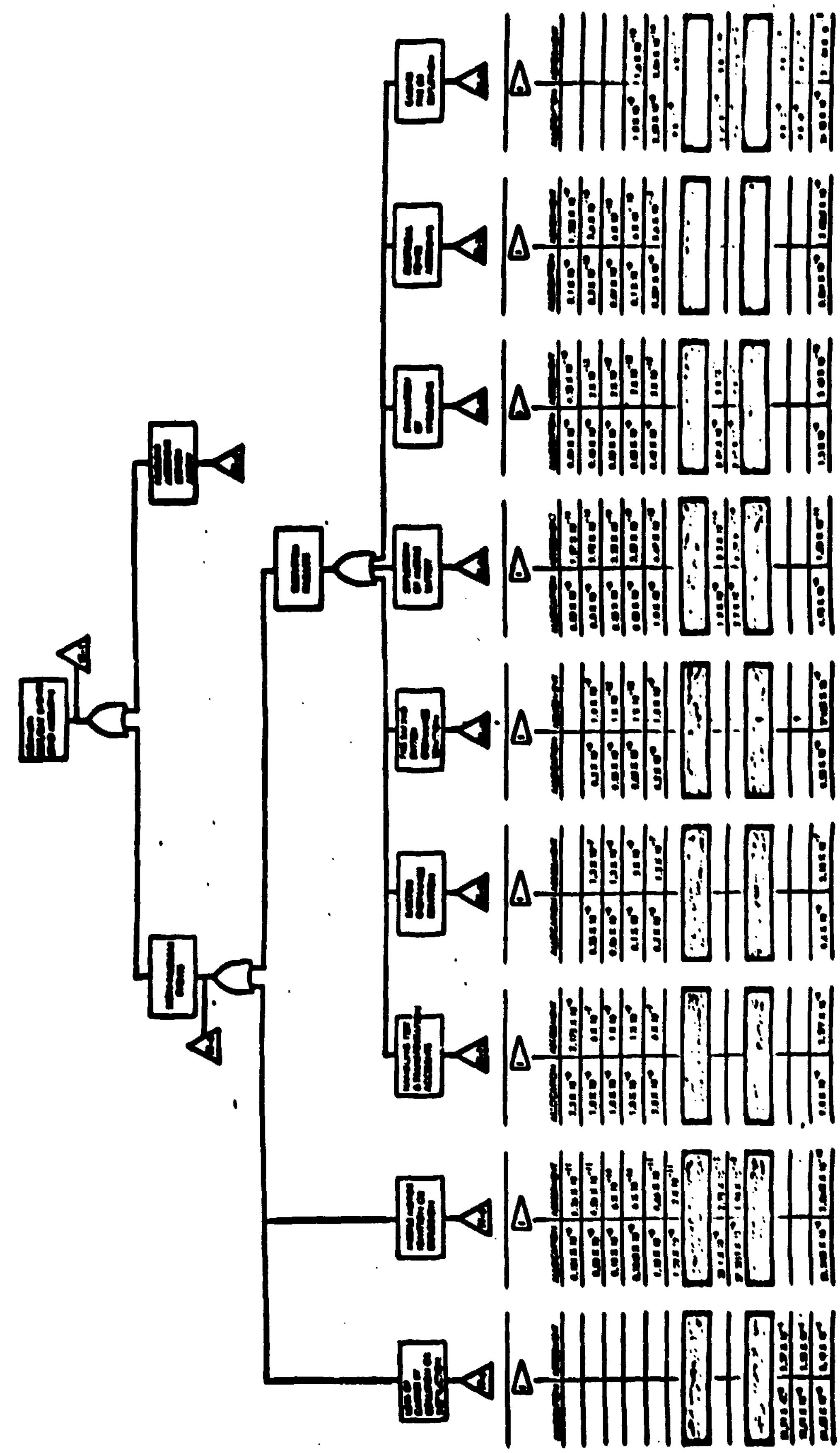
MISSION CYCLE

PER MISSILE LAUNCH

STORAGE	ASSEMBLY & CHECKOUT	LOAD TO RACK (B-52 ONLY)	LOADING & UNLOADING TO BOMB BAY OR PYLON	INTEGRATION TEST	ALERT	CAPTIVE NON-OP	CAPTIVE OP	FREE FLIGHT

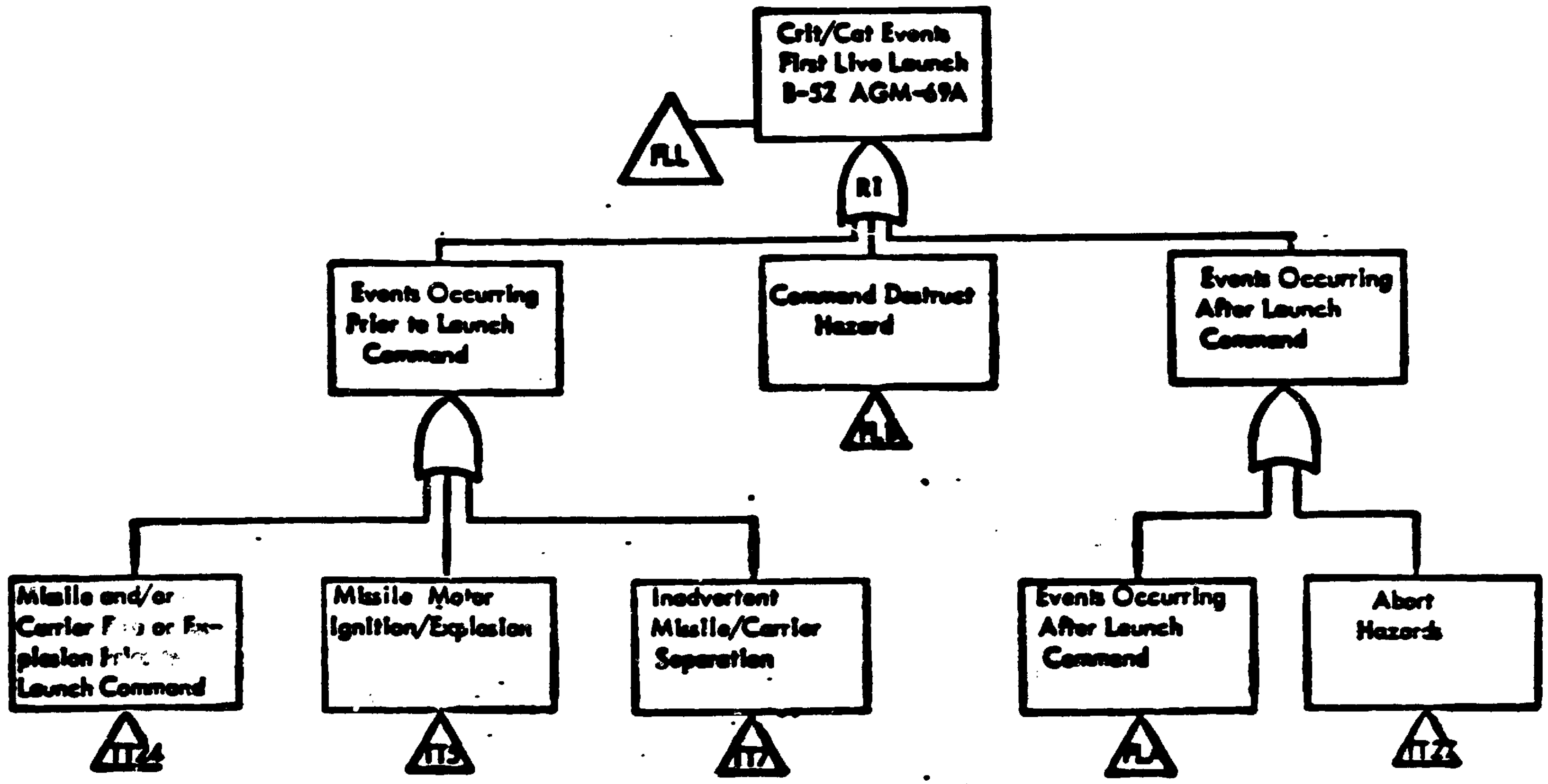


TOP FAULT TREE EWO/OTL
CRIT/CAT MISSILE LAUNCH EVENTS
AGM-69A

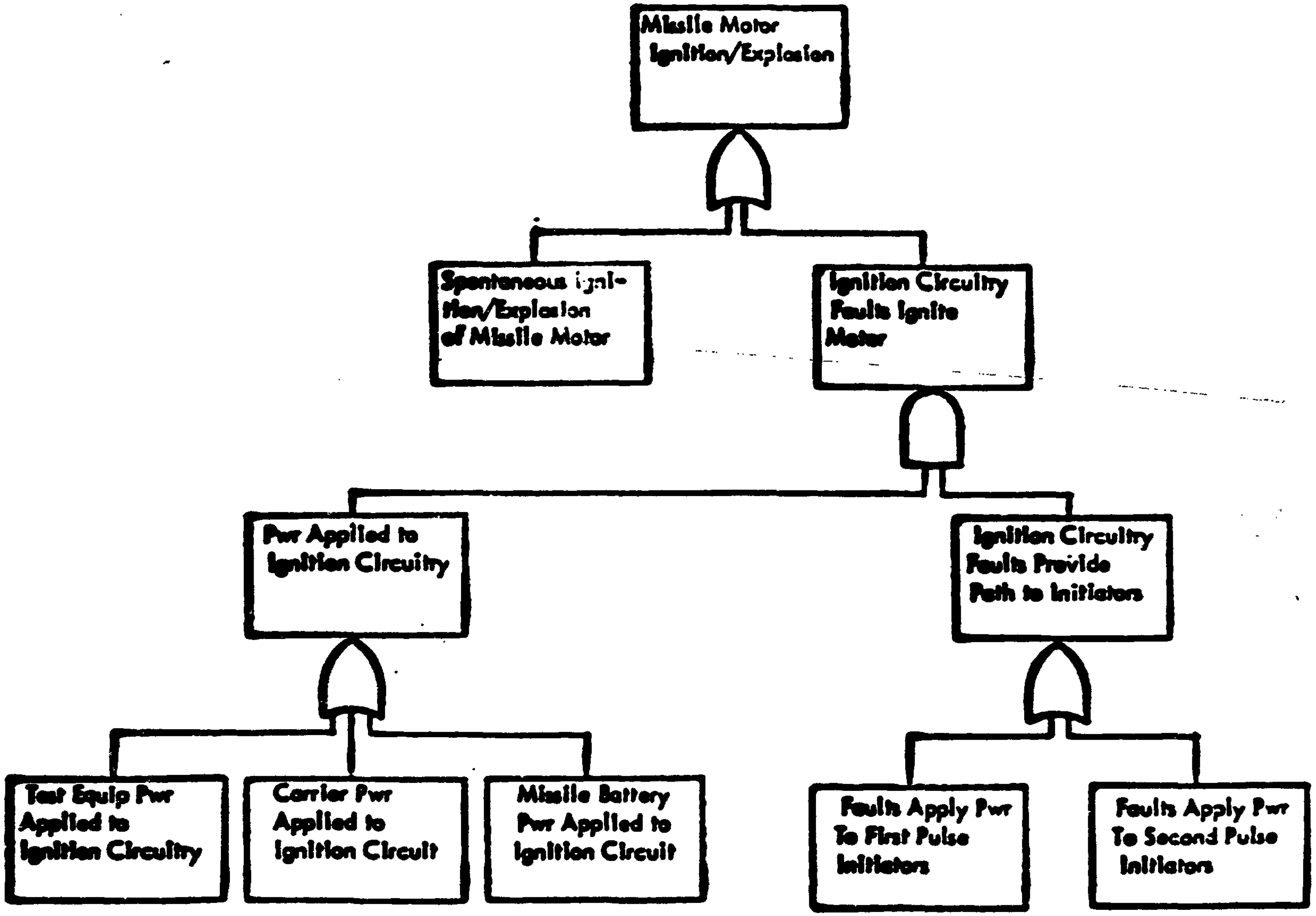


NUMERICAL DATA SOURCES

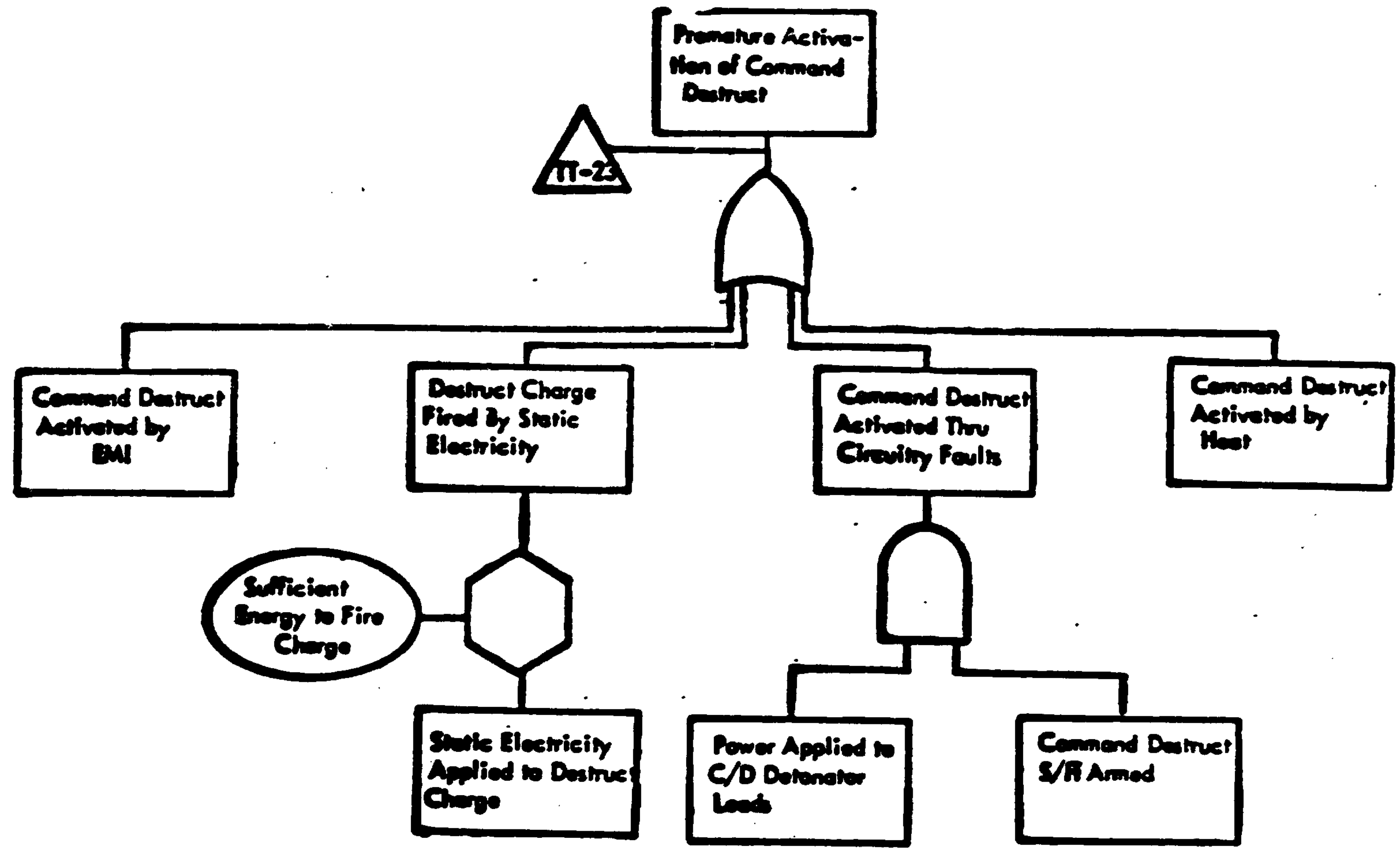
- CURRENT AGM-69A ESTIMATES
  - FAILURE MODE AND EFFECT ANALYSES
  - D2AGM12101-2 RELIABILITY ESTIMATES
  - BIOTECH HUMAN RELIABILITY ESTIMATES
  - MAINTAINABILITY ESTIMATES
- INDUSTRY AND AIR FORCE DATA CONSIDERED APPLICABLE
  - MINUTEMAN AND OTHER FAILURE RATE DATA
  - AIR FORCE ACCIDENT/INCIDENT REPORTS
  - INDUSTRIAL SAFETY ACCIDENT RECORDS
  - VENDOR HANDBOOK INFORMATION
- ENGINEERING ESTIMATES BY SAFETY ASSURANCE



Crit/Cat Events First Live Launch, B-52



Missile/Motor Ignition/Explosion



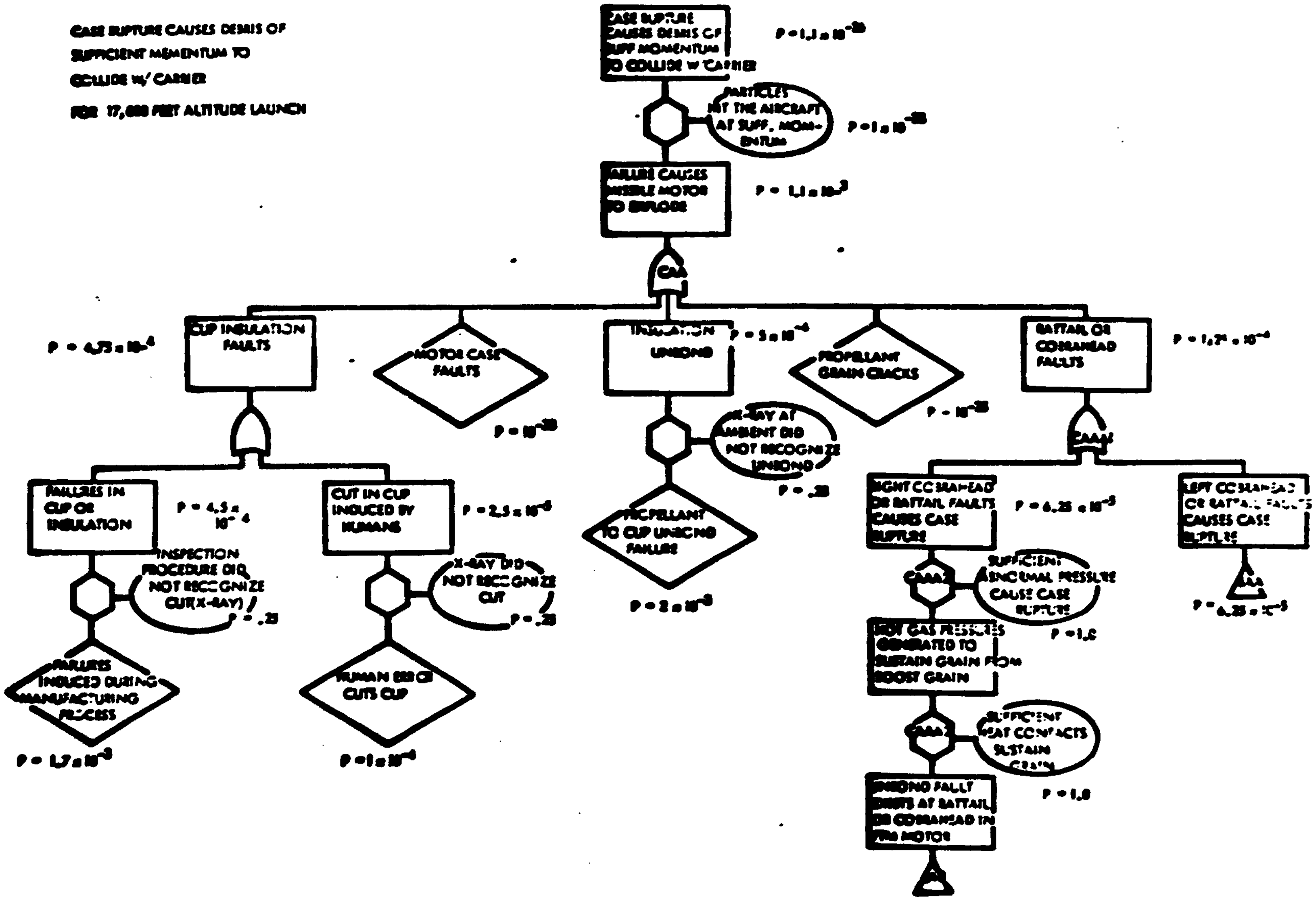
Premature Activation of Command Destruct

B-52 FIRST LIVE LAUNCH
SYSTEM SAFETY PREDICTION
$P = 1.4 \times 10^{-4}$/MISSION
(1.5 SEC. IGNITION)

HAZARD EVENTS	PROBABILITY PER MISSILE LAUNCH
PRIOR TO LAUNCH	
INADVERTENT SEPARATION	7.1×10^{-13}
INADVERTENT COMMAND DESTRUCT	8.6×10^{-8}
MISSILE MOTOR IGNITION	1.5×10^{-7}
FIRE - EXPLOSION	6.2×10^{-9}
AFTER LAUNCH COMMAND	
MISSILE CARRIER COLLISION	$\underline{1.4 \times 10^{-4}}$
RANGE SAFETY COMMAND DESTRUCT HAZARDS	3.1×10^{-9}
ABORT HAZARDS	5.7×10^{-8}

CASE RUPTURE CAUSES DEBRIS OF SUFFICIENT MEMENTUM TO COLLIDE W/ CARRIER

FOR 17,000 FEET ALTITUDE LAUNCH



Case Rupture Causes Debris of Suff Momentum to Collide with Carrier

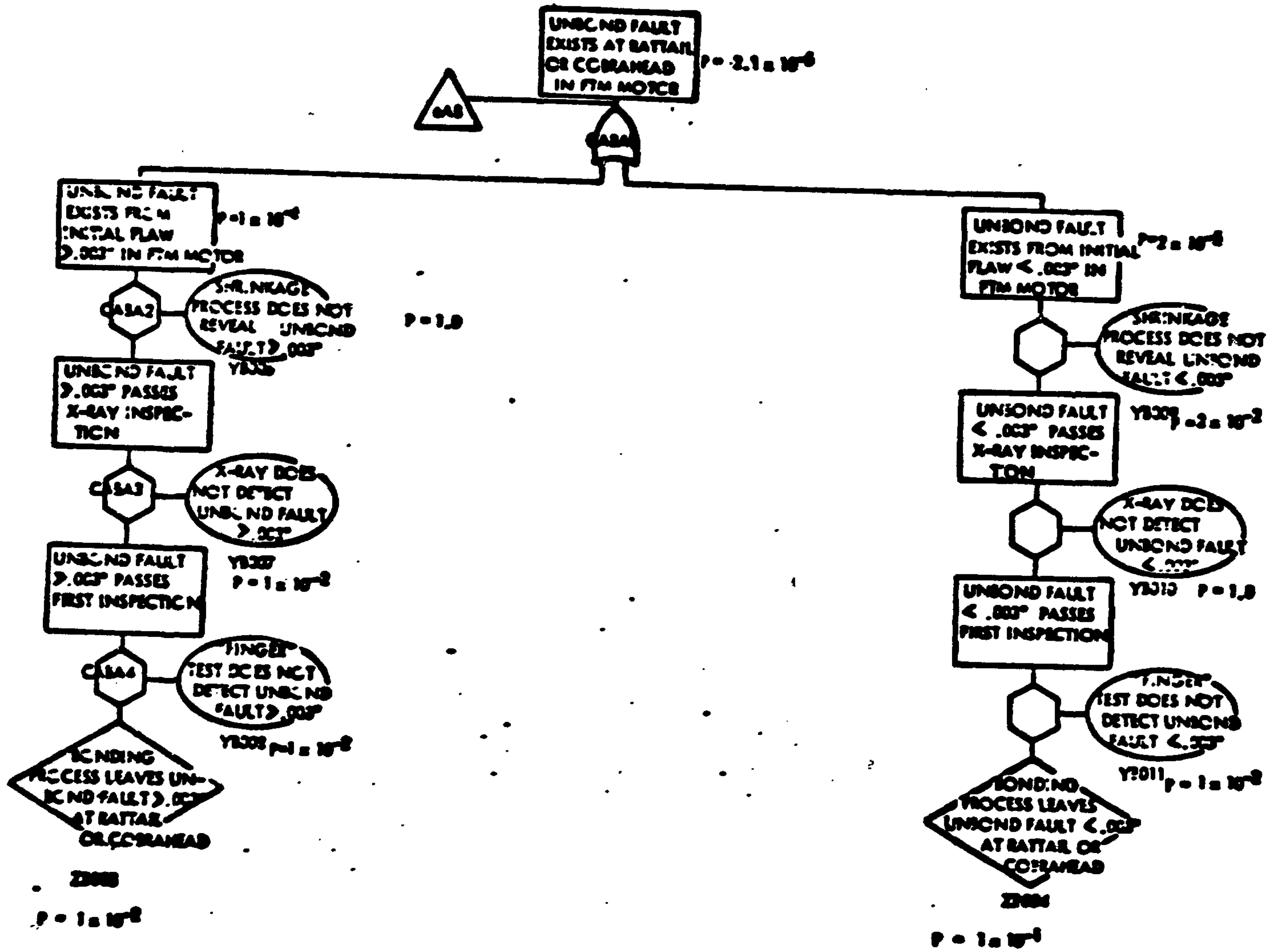
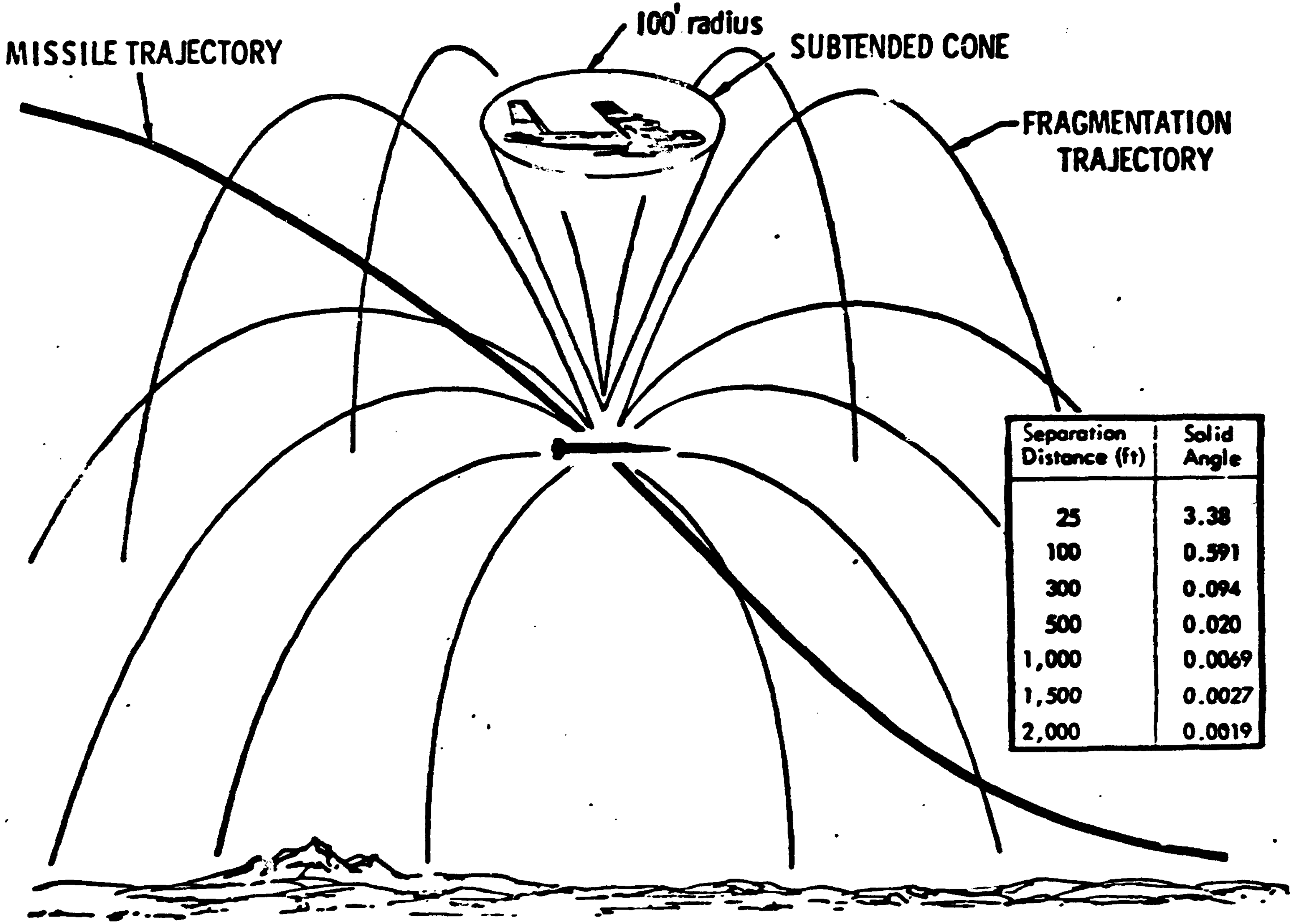


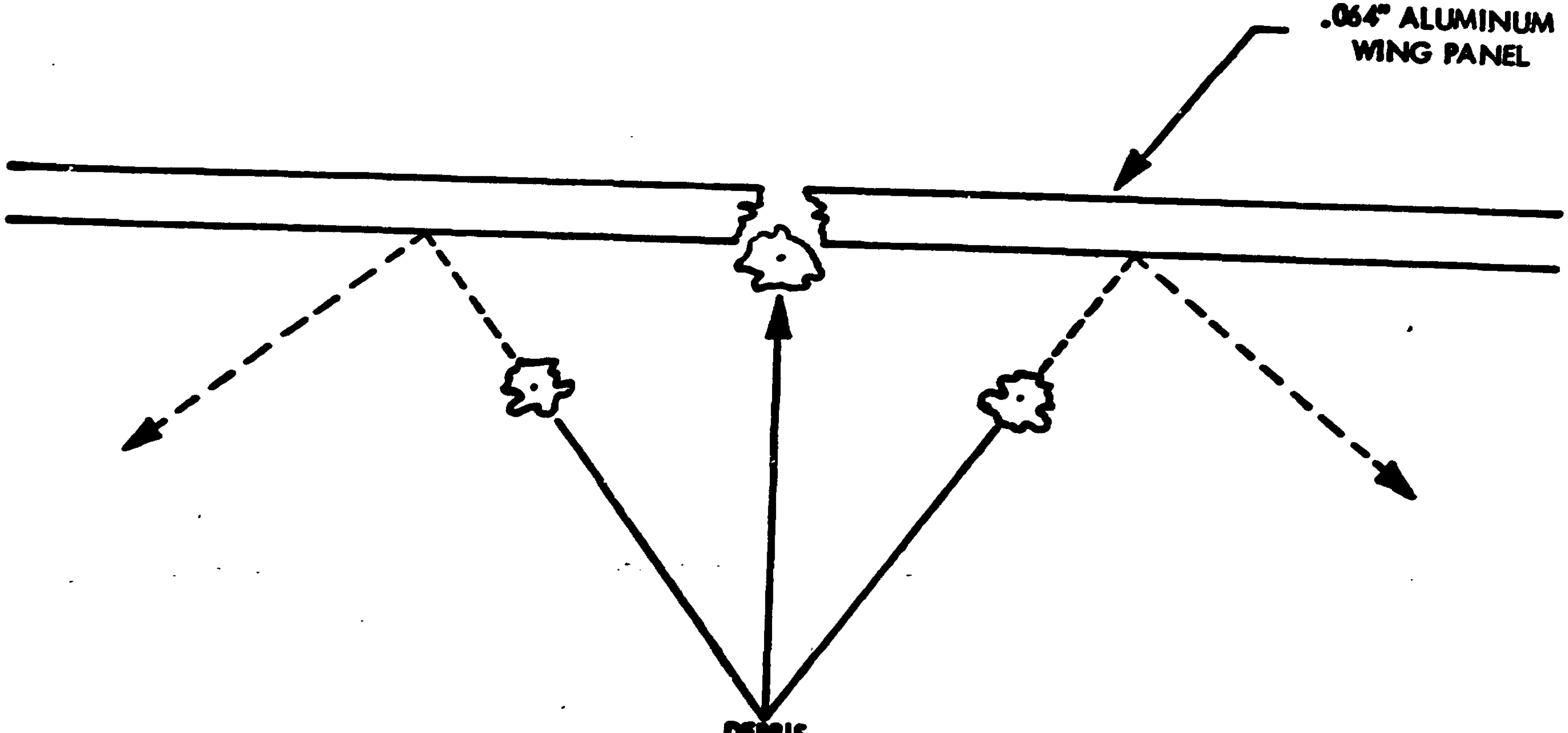
Figure 2 - Unbond Rattail or Cobrahead

CARRIER HAZARD CONE

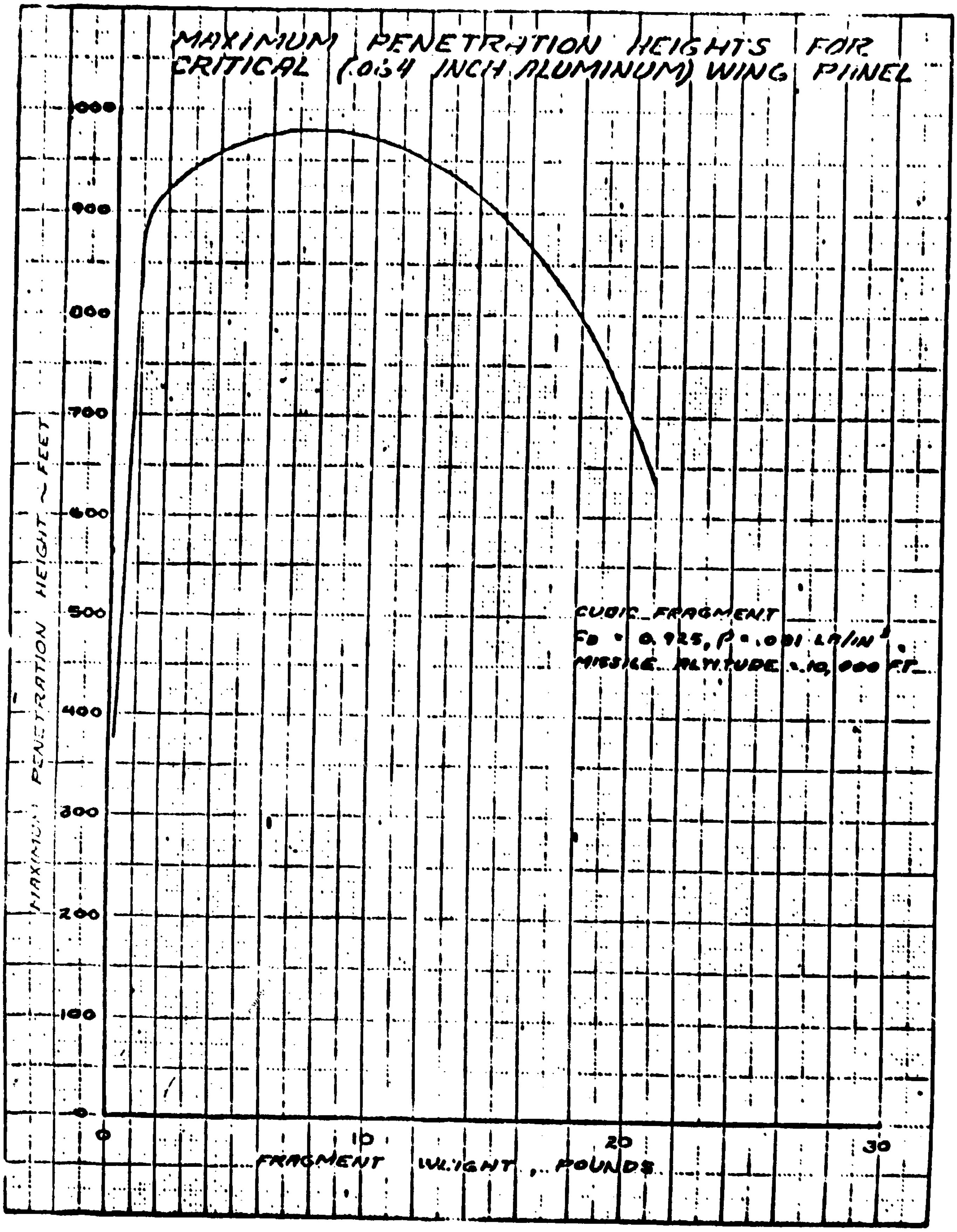


Separation Distance (ft)	Solid Angle
25	3.38
100	0.591
300	0.094
500	0.020
1,000	0.0069
1,500	0.0027
2,000	0.0019

FRAGMENTATION
PENETRATION P_p



MV^2 IS 98 FEET/SECOND FOR AN 8.5 LB. PARTICLE TO PENETRATE .064" ALUMINUM WING PANEL FOR DIRECT OR VECTOR ∠ OF 90°



MAXIMUM PENETRATION HEIGHTS FOR CRITICAL (.034 INCH ALUMINUM) WING PANEL
MAXIMUM PENETRATION HEIGHT ~ FEET
1000
900
800
700
600
500
400
300
200
100
0
0
10
20
30
FRAGMENT WEIGHT, POUNDS
CUBIC FRAGMENT
CD = 0.925, ρ = .081 LB/IN³
MISSILE ALTITUDE = 10,000 FT

PROBABILITY OF N PARTICLES TO HIT THE CARRIER AT VARYING SEPARATION DISTANCES

Separation Distance	Penetration* Probability	Probability of Single Particle Hit	Single Particle Hit & Penetration	Missile Explodes Into 25 Particles	50 Particles	100 Particles
50'	.90	.034	.0306	.530	.778	.952
100'	.8413	1.2×10^{-2}	1.009×10^{-2}	.228	.395	.634
200'	.6915	3.5×10^{-3}	2.42×10^{-3}	.059	.115	.216
300'	.50	1.53×10^{-3}	7.65×10^{-4}	1.91×10^{-2}	3.83×10^{-2}	7.65×10^{-2}
400'	.31	9.07×10^{-4}	2.81×10^{-4}	7.03×10^{-3}	1.40×10^{-2}	2.81×10^{-2}
500'	.16	5.9×10^{-4}	9.44×10^{-5}	2.36×10^{-3}	4.72×10^{-3}	9.44×10^{-3}
600'	.067	5.1×10^{-4}	3.42×10^{-5}	8.55×10^{-4}	1.71×10^{-3}	3.42×10^{-3}
700'	.023	2.94×10^{-4}	6.76×10^{-6}	1.69×10^{-4}	3.38×10^{-4}	6.76×10^{-4}
800'	.0062	2.356×10^{-4}	1.46×10^{-6}	3.65×10^{-5}	7.3×10^{-5}	1.46×10^{-4}
900'	.0013	1.77×10^{-4}	2.3×10^{-7}	5.40×10^{-6}	1.15×10^{-5}	2.30×10^{-5}
1000'	.0001	1.5×10^{-4}	1.5×10^{-8}	3.75×10^{-7}	7.5×10^{-7}	1.50×10^{-6}
1500'	4.95×10^{-12}	6.5×10^{-5}	3.22×10^{-16}	8.05×10^{-15}	1.61×10^{-14}	3.22×10^{-14}
2000'	5×10^{-20}	4.0×10^{-5}	2.0×10^{-24}	5.00×10^{-24}	1.00×10^{-23}	2.00×10^{-22}

* Penetration Probability Based on D-17 Explosion Statistics

SUMMARY OF AIR LAUNCHED MISSILE INCIDENTS

	1964 EXPLOSION	1964 COLLISION	1965 EXPLOSION	1965 COLLISION	1966 EXPLOSION	1966 COLLISION	1967 EXPLOSION	1967 COLLISION	1968 EXPLOSION	1968 COLLISION
AIR/ATR - 2 GENIE					0.0031 2		0.00191 1		0.00264 1	
AIM - 4 FALCON					0.00238 1				0.00867 4 (4)	0.00972 1
AIM - 7 SPARROW						0.0011 1 (2)	0.00195 2	0.00096 1 (3)	0.0057 4	0.00711 5 (7)
AIM - 9 SIDEWINDER	18 (1)		6		0.00709 12		0.0066 12		0.00264 3 (5)	
AIM - 26 FALCON (NUL)										
AGM 45 SHRIKE					0.00213 1					
AGM 78 STD. ARM									0.107 3 (6)	

GENERAL NOTE

FOR ALL AIR LAUNCHES FROM 1966 TO DATE ONLY 1 AIRCRAFT DAMAGED (MINOR) BY ANY MISSILE BLOW UPS - AIRCRAFT INGESTED FRAGMENT OF AGM 12C AFTER LAUNCH (MUST FOLLOW MISSILE TO GUIDE IT ON FLIGHT) FOD TO ENGINE ONLY. (21,888 LAUNCHES)

1. MOTOR SEAL FAILED (1) G&C FAILURES SELF-DESTRUCTED (6) FUZE FAILURE WHD DETONATED (3).
2. AFTER MSL EJECTION & MOTOR IGNITION MSL STRUCK AIRCRAFT UNDER LEFT WING CAUSING MINOR DAMAGE.
3. APPROX 2 SEC AFTER LAUNCH MSL DISINTEGRATED - WHD & G&C UNIT SEPARATED. DEBRIS STRUCK PYLON TANK - VERY MINOR DAMAGE.
4. (1) MOTOR EXPLODED 500' IN FRONT - 200' LEFT OF AIRCRAFT - GRAIN CRACK IN MOTOR - NO AIRCRAFT DAMAGE.
   (2) SELF DESTRUCT MALFUNCTION - BLEW UP 2.8 SEC AFTER LAUNCH - NO AIRCRAFT DAMAGE.
5. 2 SEC AFTER LAUNCH MOTOR EXPLODED - 2 WHD DETONATED PREMATURELY - FUZE PROBLEM - NO DAMAGE TO AIRCRAFT.
6. DUE TO G&C PROBLEMS - ROLL INSTABILITY CHANGED GAS EJECTION PATTERN - GOT HOT SPOT AND MOTOR BLEW - NO AIRCRAFT DAMAGE.
7. SEPARATION PROBLEMS - WHEN JETTISONED MSL STRUCK OTHER WEAPONS OR MISSILES - NO AIRCRAFT DAMAGE. FIN CAME OFF AND STRUCK AIRCRAFT - MINOR DAMAGE.

- Probability of Air Launched Missile/Aircraft Accident = 5.5×10^{-5}/launch (70%)
- Probability of Missile Motor Explosion After Launch = 2.33×10^{-3}/launch

THE SAFETY ASPECTS OF THE INERT-DILUENT PROCESS AS APPLIED TO PROPELLANTS PROCESSING

Larry D. Henderson
U.S. Naval Ordnance Station, Indian Head, Md.

The Naval Ordnance Station is actively investigating continuous processing techniques usable for rocket propellants. One of these techniques, the Inert-Diluent process has been under study for the past nine years. This process is based on the Quickmix process patented by Rocketdyne Division of North American Rockwell. This process has the advantage that all of the propellant ingredients investigated are desensitized when held in emulsion or suspension in the heptane carrier, in the line sizes encountered in the process, and at concentration greater than /those used in the process. The results of early safety tests have shown that, by separation of the various processing areas, no chance existed for transmittal of an explosion from one processing area to another by means of the process. Since small quantities of material are in process at any instant, the chance of having an incident of large magnitude (such as have occurred in large batches of explosives) is greatly reduced.

The Naval Ordnance Station currently has two Inert Diluent facilities. A pilot plant, which has the capacity for one thousand pounds per hour or less and where quantities of up to five thousand pounds may be processed, and a larger facility where a maximum rate of twenty-five hundred pounds per hour may be produced in quantities of thirty thousand pounds. Both facilities use similar equipment, but the larger facility has considerably more sophisticated equipment and buildings.

Of particular interest within the Inert Diluent Process are remotely controlled solids handling systems and casting systems.

The solid feeder, developed for this process, does not use the conventional belts or screw conveyors, normally associated with continuous solid feeders. Instead the feeder uses a weighing mechanism which greatly reduces the friction imposed upon the solids. A small weighing hopper, which holds less than one pound of typical explosive solid ingredients, has been fitted with a bottom discharge valve.

This valve is similar in form to the commercially available Red Jacket Valve but is constructed of fifty thousandths (0.050") thick rubber tubing enclosed in a light gage metal housing. When the annular space between the metal housing and the rubber tubing is pressurized (with between three and four pounds per square inch gage air), the rubber tube gently reduces in diameter, folds, and closes off the discharge orifice of the hopper. This sphincter-like action gently shuts off flow from the weigh hopper.

In both IDP facilities the solids from manually loaded hoppers flow through the special solid feeders to a pump agitated solids/carrier dispersion vessel. The solids are then transported as slurries in heptane to the mixing point where they are mixed with the carrier emulsified explosive plasticizer. The carrier is decanted in a stilling vessel while the explosive mix is either degassed into a casting pot or directly into a rocket motor or other casting configuration at 10 mm Hg absolute pressure.

In the pilot plant the explosive flows through hoses into two alternately filled, evacuated, casting pots. As the explosive enters the casting pot it is degassed by passing through a slit plate. When a casting pot is full, as observed by closed circuit television on a dial type weight indicator, by addition of controlled nitrogen the remaining free volume is slowly brought to a pressure sufficient to transfer the explosive through a casting manifold into rocket motors which have previously been placed on hand carts. After the IDP process has been shut down, these carts are manually moved to separate curing facilities.

Control of the casting is done via remotely controlled Saunders valves and Red Jacket valves, with the aid of closed circuit television.

In the larger IDP facility the explosive material flows through the separator, transfer hose, and slit degassing device, directly into a rocket motor positioned in an evacuated casting vessel. This casting vessel is a stainless steel clad pit fifteen feet in diameter by thirty feet deep with vacuum

capability. A series of several castings may be positioned on a turntable system which is utilized to position the motors directly beneath the slit degassing device. Operation of the system is so interlocked as to avoid underfill or overfill. Rotation of the turntable is interlocked to the casting system so that explosive may only flow into an empty or filling rocket motor, never into a full unit. Explosive drips are caught on either Teflon-lined trays or on electrically conductive plastic sheets. The casting operation is easily observed over a closed-circuit television system. Operator override is possible on the system, but only to shut off the flow of explosive or stop rotation of the turntable. Capacitance or float type level switches are used to shut off explosive flow into the rocket motor when it is full. After casting, the vacuum on the casting vessel is slowly released with nitrogen and curing remotely programmed for the cast-in-place rocket motors. After curing, the lid to the casting pit is removed and the motors are transferred for final inspection, assembly, and shipment. The scrap explosive is easily peeled from the hardware after it is cured. At the end of a run all explosive transfer hoses are washed with heptane into a scrap vessel located in the casting pit.

In both facilities no personnel are exposed to explosives during mechanical handling of the material. In all cases all of the operators remain in concrete blockhouses several hundred feet from the casting process so that exposure to uncured material is minimized or eliminated.

Comments:

Discussion and comments on IDP centered around technical aspects of the process rather than the safety aspects. These included:

a. A discussion on the moisture removal qualities of carrier liquid during processing and the capability of removing the carrier from the matrix to below the detectable range prior to cure of the cast material. Formulations processed in the 50,000 to 100,000 cp viscosity range that were vacuum cast and deaerated, gave essentially voidless castings. The process is particularly well suited to double-base formulations in this viscosity range.

b. A discussion on the suitability of IDP for other formulations revealed that composite and cross-linked formulations were not well suited. A Rocketdyne representative declared that they were looking at the suitability of the system to process Tritonol and H-6 using water as a carrier. Comments from others questioned the removal of water (below 2% level) from TNT but agreed that it may be a safer operation in that it would reduce the number of people normally exposed to the melt and load operation.

c. Other comments were on the wisdom of applying continuous and remote processes and technology of this type to explosive fill operations. The consensus was that it would be a good move.

DEPARTMENT OF DEFENSE EXPLOSIVES SAFETY BOARD
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DDESB-KMC

07 JUL 2000

MEMORANDUM FOR DDESB RECORDS

SUBJECT: Declassification of Explosives Safety Seminar Minutes

References: (a) Department of Defense 5200.1-R Information Security Program, 14 Jan 1997

(b) Executive Order 12958, 14 October 1995 Classified National Security Information

In accordance with reference (a) and (b) downgrading of information to a lower level of classification is appropriate when the information no longer requires protection at the originally level, therefore the following DoD Explosives Safety Seminar minutes are declassified:

a. AD#335188 Minutes from Seminar held 10-11 June 1959.
b. AD#332709 Minutes from Seminar held 12-14 July 1960.
c. AD#332711 Minutes from Seminar held 8-10 August 1961.
d. AD#332710 Minutes from Seminar held 7-9 August 1962.
e. AD#346196 Minutes from Seminar held 20-22 August 1963.
f. AD#456999 Minutes from Seminar held 18-20 August 1964.
g. AD#368108 Minutes from Seminar held 24-26 August 1965.
h. AD#801103 Minutes from Seminar held 9-11 August 1966.
i. AD#824044 Minutes from Seminar held 15-17 August 1967.
j. AD#846612 and AD#394775 Minutes from Seminar held 13-15 August 1968.
k. AD#862868 and AD#861893 Minutes from Seminar held 9-10 September 1969.

The DoD Explosives Safety Seminar minutes listed above are considered to be public release, distribution unlimited.

DANIEL T. TOMPKINS
Colonel, USAF
Chairman

Attachments:
1. Cover pages of minutes

cc:
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AD861893L

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MINUTES
OF THE ELEVENTH
EXPLOSIVES SAFETY SEMINAR

SHERATON-PEABODY HOTEL
MEMPHIS, TENNESSEE
9-10 SEPTEMBER 1969

VOLUME II

Conducted by
ARMED SERVICES EXPLOSIVES SAFETY BOARD
Washington, D. C. 20315

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